

VID1: Analog Video and Color

By Prof. Gregory D. Durgin

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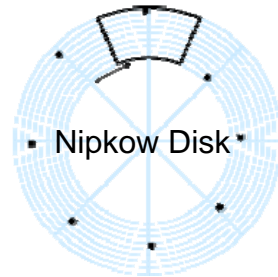
Outline of this Topic

- Analog Intensity Video Signals
- Forms of Amplitude Modulation
- Analog Color Signal Structure
- Quadrature Amplitude Modulation
- Analog Video over Satellites
- FM Modulation



Mechanical Television?!

- Original idea for *mechanical* television
 - Invented by Paul Gottlieb Nipkow in Germany (1884)
 - Based on a spinning disk
 - Never made fast enough for effective video viewing
- Russian Mirror & Drum technique
 - Invented by Leon Theremin (1927)
 - Theremin also invented...
 - Famous US Embassy Bug
 - RF Motion Detector
 - Musical Instrument (Thereminvox)

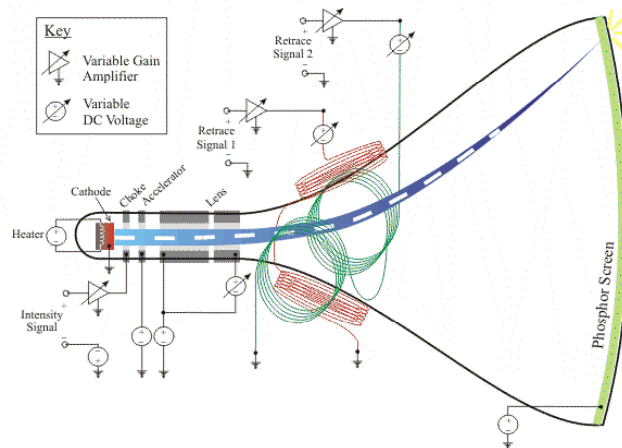


*from Wikipedia

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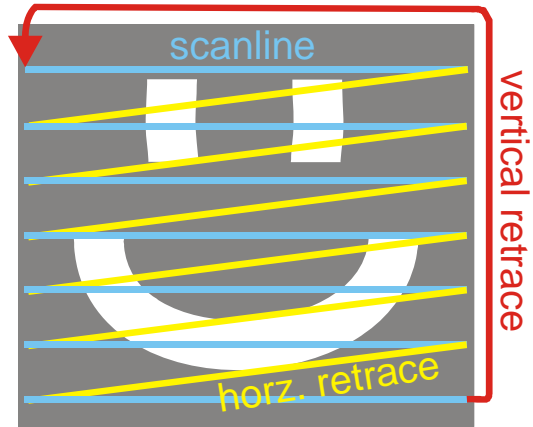
Cathode Ray Tube – How it Works



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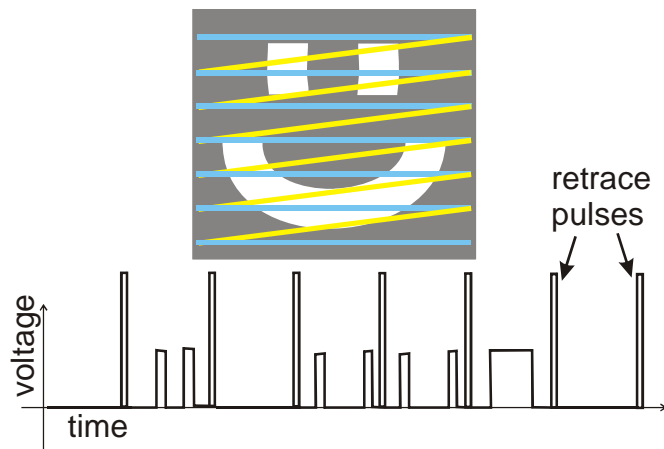
How an Intensity Image is Displayed



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Analog Video Intensity (Luma) Signal



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First US Television Standard

- black and white TV (first public station in 1941)
- 525 scan lines (428 visible lines)
 - Vertical dimension is “digital”
 - Bottom lines are part of “vertical blanking interval”
 - VBL carries synch info, close-captioning, DGPS...
- 30 frames per second
- interlaced (updates every other scan line)

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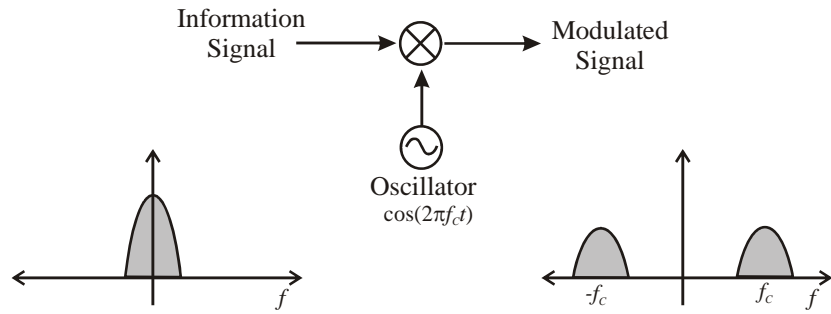
Candidates for Simple AM Modulation

- Large/Small-Carrier AM (SC-AM or LC-AM)
 - Standard AM is bandwidth
- Single-Sideband (SSB) AM
 - Bandwidth efficient, but difficult to implement
 - Vestigial Sideband (VSB) AM is a good compromise
- FM Transmission
 - Trades-off extra bandwidth for signal fidelity
 - Also bandwidth inefficient

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Basic Amplitude Modulation

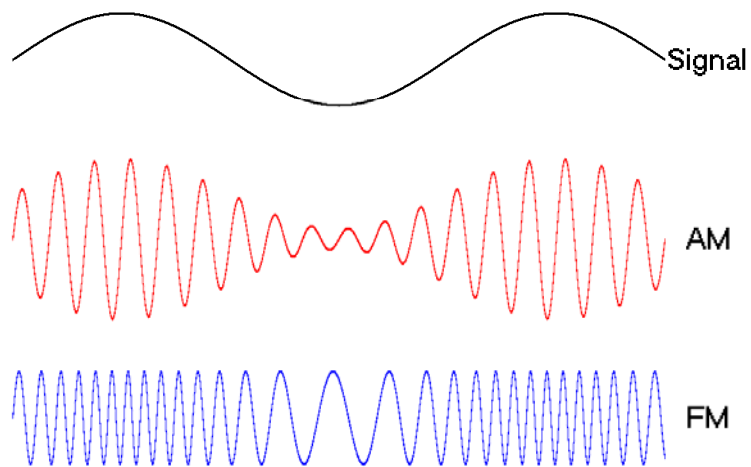


Intensity signal has about 5 MHz of bandwidth (10 MHz RF)

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What an SC-AM Signal Looks Like

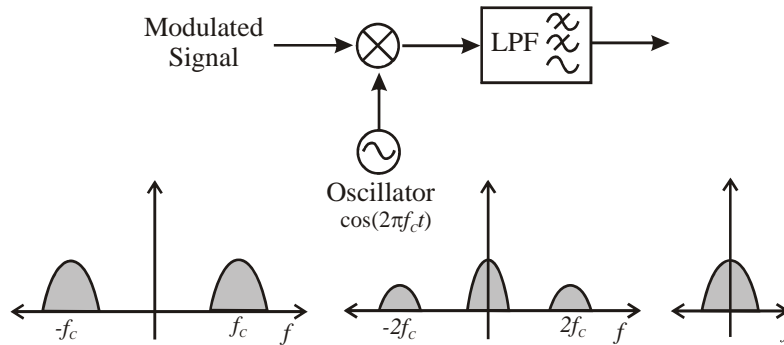


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Basic AM Receiver Block

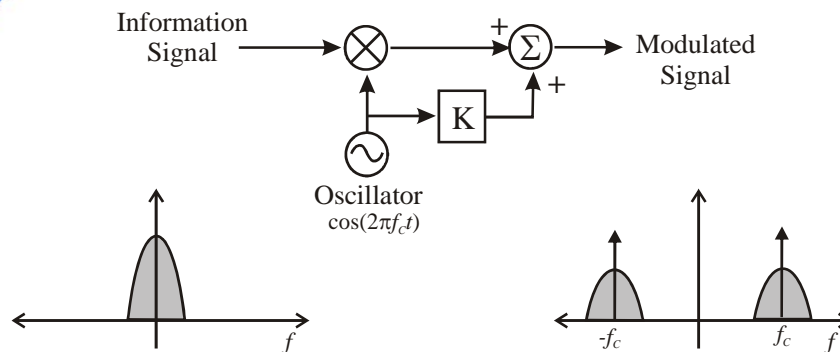


- Ideal small-carrier AM receiver
- Impractical if inexact oscillator used at the RX

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Large-Carrier AM Signal Generator

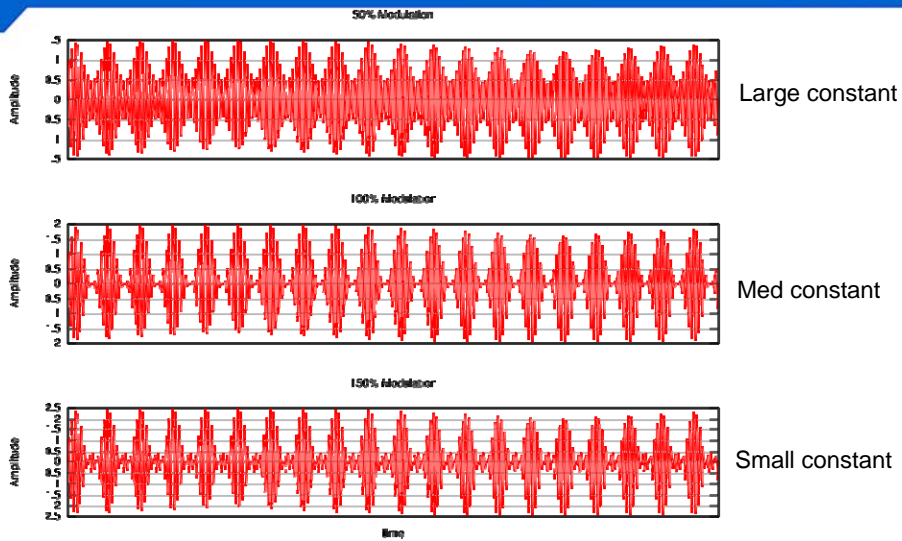


- Add the carrier back into the SC-AM signal
- Same bandwidth as SC-AM
- Cheap receiver – can use an envelope detector to demod.

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Effect of Adding DC-Offset to SC-AM



Large constant

Med constant

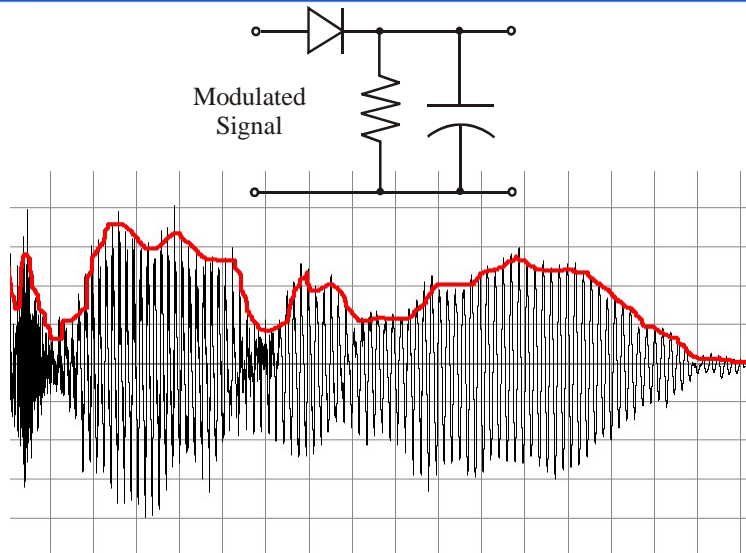
Small constant

*from Wikipedia



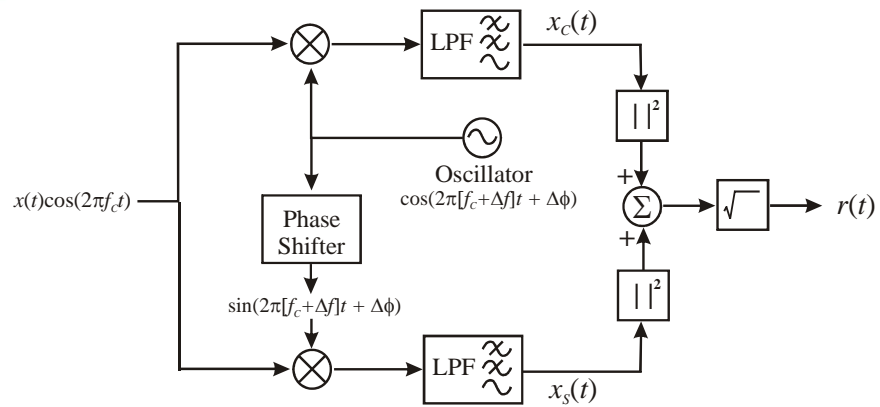
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Envelope Detector for LC-AM



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Amplitude Modulation – Ideal RX

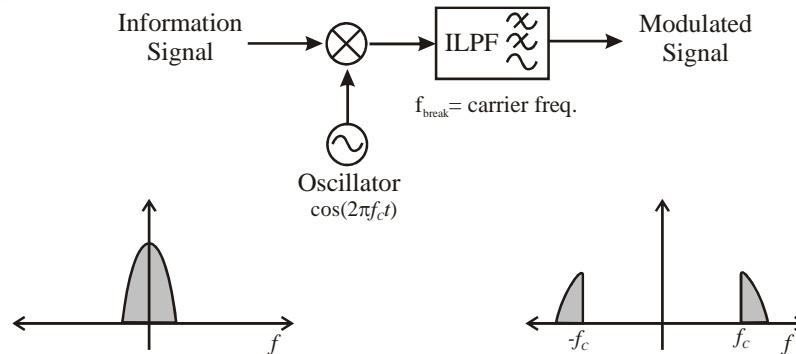


Recovers AM signal without a perfect oscillator

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Single-Sideband AM

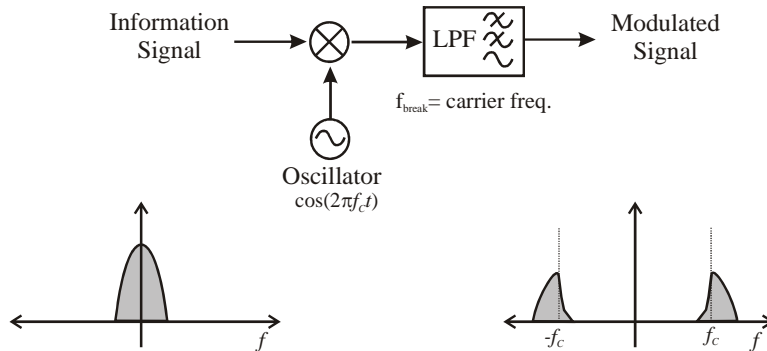


- Idealized modulator shown above
- Real implementation would require intermediate freq.
- Upper or Lower sideband implementations possible

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Vestigial Sideband (VSB) Modulation



- Real VSB modulator would use intermediate frequencies
- VSB can be generated with realistic filters
- Good trade-off between SC-AM and SSB-AM

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Adding Color to Analog Video

- First Public Color TV Broadcast in 1953
- National Television System Committee (NTSC)
- Required backwards compatibility
 - Black-and-white TVs must still receive and reproduce a believable image transmitted in color
 - Color TVs must reproduce black-and-white video
 - Signal must fit within the same 6 MHz of VSB bandwidth (no spectrum re-allocations)

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Classic "Artistic" Primary Colors

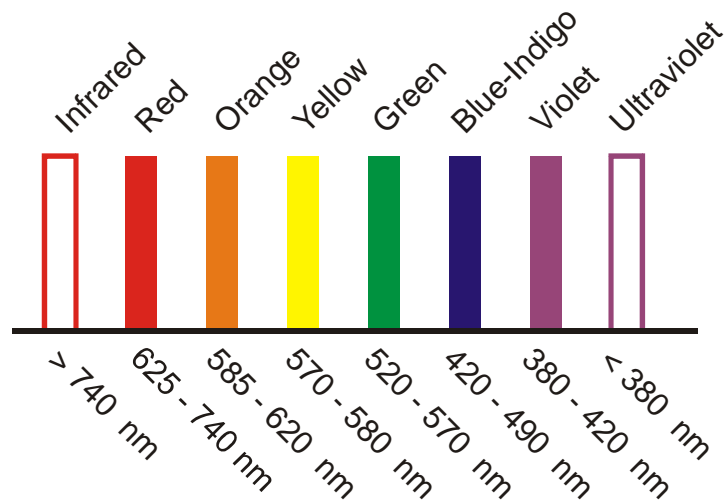


- Blue Yellow Red standard color wheel
- Non-mathematical collection of subtractive primaries
- Useful for artistic expression of color (mixing paints and pigments)

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Optical Spectrum and Color



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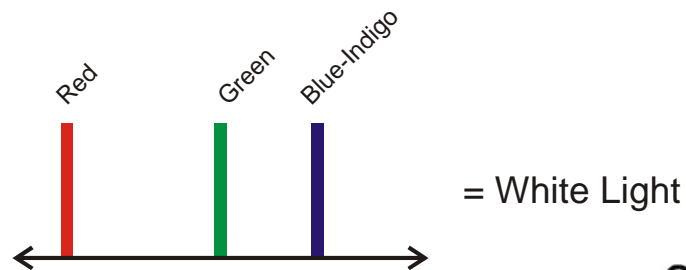
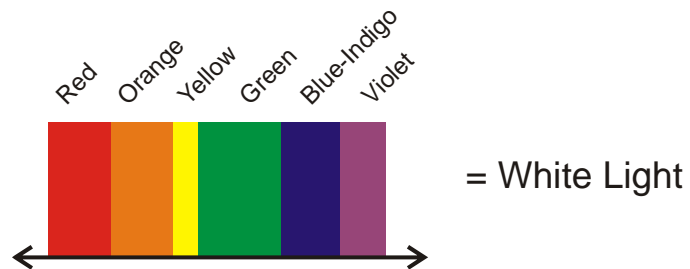
Metamerism: Color in the Human Eye

- Cone cells detect color by frequency
 - only 3 kinds of cone cells
 - short (blue), medium (green), long (red) wavelengths
 - all colors may be reduced to these tri-stimulus values
- Red-Green-Blue palette forms additive primaries
 - can stimulate nearly all visible colors from RGB
 - each color has more than one possible spectrum

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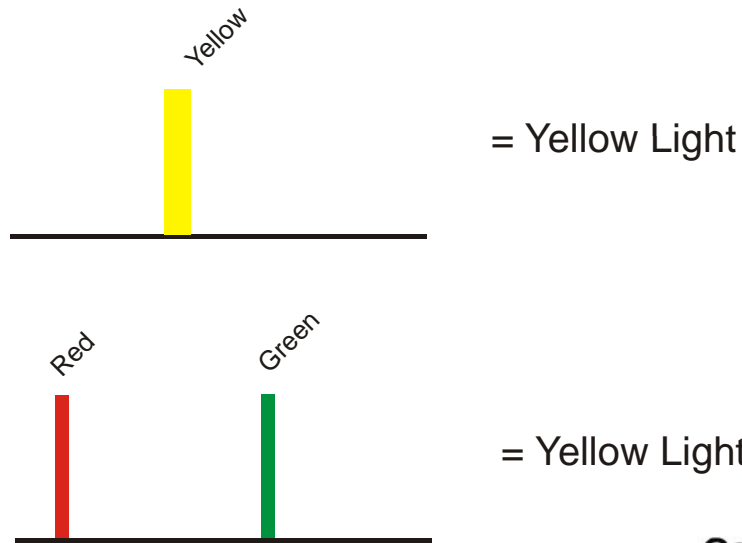
Example Metamer: White Light



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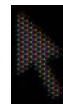
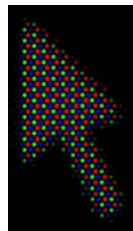
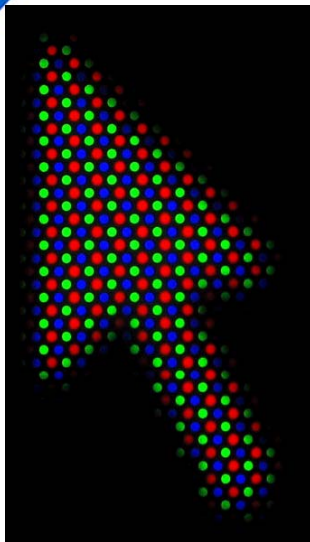
Metamer Example: Yellow Light



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Adding Color to Analog Television



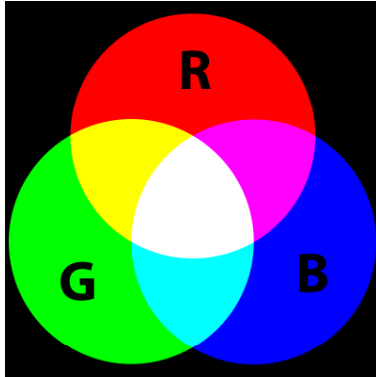
- CRT uses 3 separate electron guns
 - 1 red, 1 green, 1 blue
 - Metallic shadow mask separates color beams
- Requires 3 separate video signals
- Capable of generating wide range of colors (called the *gamut*)

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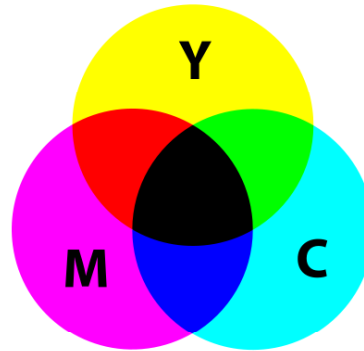
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“Scientific” Primary Colors



Red – Green – Blue
Additive Primaries



Cyan – Magenta – Yellow
Subtractive Primaries

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Proportion and Intensity in RGB

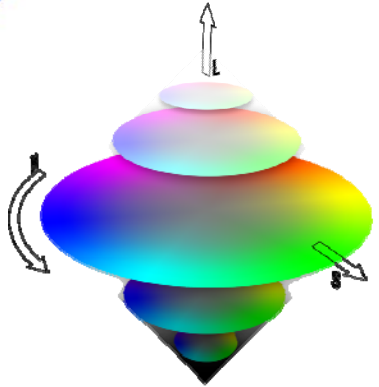
Love Poem Taken from a GT Student Facebook Page...

Roses are #FF0000
Violets are #0000FF
All my base
are belong to you

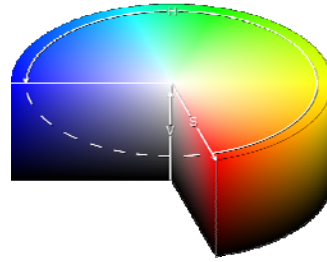
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Other RGB-Based Color Schemes



Hue - Saturation - Light



Hue - Saturation - Value

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*from Wikipedia